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8860A
Digital Multimeter

Calibration Manual

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8860A

Digital Multimeter

Calibration Manual

P/N 541276
April 1980

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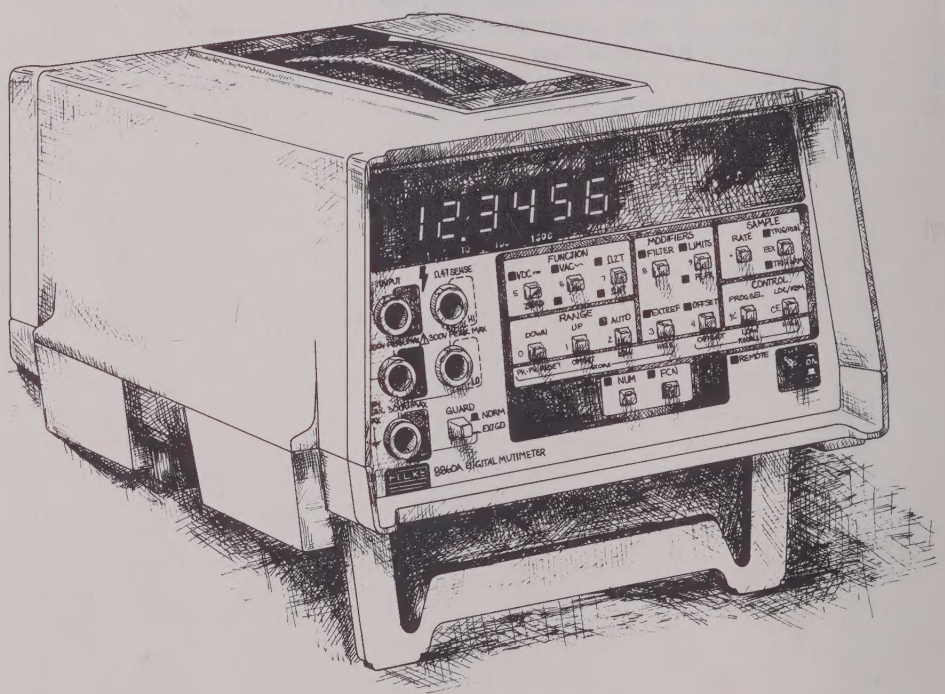

8860A Digital Multimeter

Section 1
Introduction and Specifications

1-1. THE 8860A INSTRUCTION MANUAL SET

1-2. The John Fluke Model 8860A Digital Multimeter is documented by a set of five manuals: Operator, Calibration, Calculating Controller User Handbook, Service, and a Reference Guide. The Operator Manual includes a description of the unit, installation information, operating instructions, and routine operator maintenance. The Calibration Manual is designed for use by the Calibration Technician. It contains specifications, general maintenance information, access procedures, performance tests, and calibration adjustment procedures. The User Handbook contains the operating instructions for the Calculating Controller Option (-004). The Service Manual contains the theory of operation, troubleshooting information, a list of replaceable parts, and schematics. Condensed operating information for both the 8860A and the Calculating Controller are included in the Reference Guide. The five manuals can be separated for use in different areas or joined together in a single three-ring binder.

1-3. The Calibration Manual is divided into the following sections:

1 INTRODUCTION AND SPECIFICATIONS	Introduces the 8860A Instruction Manual Set, lists the recommended test equipment required to complete the performance tests and the calibration adjustments, and lists the instrument specifications.
2 SHIPPING AND SERVICE INFORMATION	Provides unpacking and shipping information. Instructions for contacting your local Fluke Service Center and the John Fluke Mfg. Co. Inc. are also included.
3 ACCESS PROCEDURES	Describes how to access the calibration adjustments and general maintenance circuit areas.
4 GENERAL MAINTENANCE	Includes procedures for fuse replacement, line voltage selection, and other general maintenance.
5 PERFORMANCE TEST	Provides a set of procedures to verify that the 8860A is performing within the specifications listed in Section 1. All of these procedures are accomplished without removing the instrument from its case.

6 CALIBRATION ADJUSTMENTS

Provides a set of step by step procedures for making all of the 8860A calibration adjustments. These procedures are performed when the 8860A does not meet the specifications listed in Section 1.

1-4. RECOMMENDED TEST EQUIPMENT

1-5. The equipment required to complete the Performance Test and the Calibration Procedure is listed in Table 1-1. If the recommended models are not available, instruments with equivalent specifications can be substituted.

1-6. SPECIFICATIONS

1-7. The specifications for the 8860A are listed in Table 1-2.

Table 1-1. Recommended Test Equipment

INSTRUMENT TYPE	MINIMUM SPECIFICATIONS	RECOMMENDED MODEL
AC Calibrator	Voltage Range: 0-1000V ac Freq. Range: 20 Hz-300 kHz Voltage Accuracy: 0-100V ac: 20 Hz- 50 Hz .1% 50 Hz- 10 kHz .03% 10 kHz-100 kHz .03% 100 kHz-300 kHz .4% 100-1000V ac: 20 Hz- 50 Hz .15% 50 Hz- 10 kHz .05% 10 kHz-100 kHz .1%	JF 5200A, JF5205A
DC Calibrator	Voltage Range: 0-1000V dc Accuracy: .003%	JF 332B
Voltage Divider	Ratio Range: 0-1.0 Absolute Linearity: ±1 ppm of input at dial setting	JF 720A
Resistor Decade	Resistance Accuracy: .005%	
Oscilloscope	General purpose with 10M probe	Tektronix T932A
Digital Voltmeter	Voltage Accuracy: .01% (V dc) 1.0% (V ac) for 1 volt input at 100 kHz Input Impedance: 10 Megohm or greater in V dc 1 Megohm in parallel with <100 pF in V ac	JF 8800A

Table 1-2. 8860A Specifications

DC VOLTS

Ranges ..... ±200 mV, 2V, 20V, 200V, 1000V

Ranging ..... Fully automatic or manual

Polarity of Input ..... Automatic polarity selection and display

Resolution (Max.) ..... 0.0005% of full scale (1 uV on 200 mV range) with 5-1/2 digit display.

Accuracy ..... Using front panel zero, ±(% input + no. of digits)

5-1/2 DIGIT DISPLAY*

RANGE	24 HR 23°C ±1°C	90DAY 18°C - 28°C	1 YR 18°C - 28°C	NORMAL MODE REJECTION	
				NO FILTER	FILTER
200 mV	(0.004 + 3)	(0.008 + 3)	(0.01 + 3)	>60 dB 50, 60 Hz	>100 dB 50, 60 Hz
2V-200V	(0.004 + 2)				
1000V					

4-1/2 DIGIT DISPLAY*

RANGE	90DAY 18°C - 28°C	1 YR 18°C - 28°C	NORMAL MODE REJECTION	
			NO FILTER	FILTER
All	(0.01 + 2)	(0.015 + 3)	>60 dB 50, 60 Hz	>100 dB 50, 60 Hz

*Settling Time: 30 ms to within .01% of input step size, with filter 300 ms.

3-1/2 DIGIT DISPLAY (Available with -004 or -005 options only)

RANGE	1 YR 18°C - 28°C	NORMAL MODE REJECTION	
		NO FILTER	FILTER
All	(0.1 + 1)	None	>40 dB 50, 60 Hz

Settling Time: 5 ms to within .1% of input step size, with filter 250 ms.

Common Mode Rejection

CONDITIONS ..... Line frequency switch properly set.
Line frequency at 50 or 60 Hz ±0.1%.
One kilohm in either lead.

4-1/2 AND 5-1/2 DIGIT RATE
- Normal Guard ..... >130 dB
- External Guard (Driven) ..... >150 dB

3-1/2 DIGIT RATE
- Normal Guard ..... >70 dB
- External Guard (Driven) ..... >90 dB

DC, ALL READING RATES .... >160 dB

Input Resistance

200 mV, 2V RANGES ..... >10,000 MΩ

20V, 200V, 1000V RANGES .... 10 MΩ

Table 1-2. 8860A Specifications (cont)

Input Bias Current (@ 23°C) ..... <100 pA
Zero Stability
(after 1 hour warmup) ..... ±10 uV for 90 days
Maximum Input ..... ±1000V Pk input HI to LO
±500V Pk input LO to Earth
±30V Pk input LO to Guard

AC VOLTS (True RMS, AC only or AC + DC)

Ranges ..... 200 mV, 2V, 20V, 200V, 700V

Ranging ..... Fully automatic or manual

Resolution (Max) ..... 0.0005% F.S. (1 uV on 200 mV range) with 5-1/2 digit display.

Accuracy ..... ±(% INPUT + DIGITS), 0.5% F.S. to F. S. AC only*

FREQUENCY	RANGE(S)	90 DAY 18°C-28°C			1 YR 18°C-28°C		
		% INPUT	DIGITS		% INPUT	DIGITS	
			5-1/2	4-1/2		5-1/2	4-1/2
20 Hz-50 Hz	All	0.25	70	10	0.25	100	13
50 Hz-10 kHz	All	0.15	70	10	0.15	100	13
10 kHz-50 kHz	2V-700V	0.4	150	18	0.4	300	33
	200 mV	0.7	150	18	0.7	300	33
50 kHz-100 kHz	2V-700V				1.0	350	38
	200 mV				2.5	350	38
100 kHz-300 kHz	All				8.0	700	73

*For AC + DC operation, add 0.1% of input +50 digits for 5-1/2 digit resolution.
For AC + DC operation, add 0.1% of input + 5 digits for 4-1/2 digit resolution.

Bandwidth (typical) ..... ⩽ 3 dB @ 1 MHz

Crest Factor ..... 3 at full range, increasing down range

Input Impedance ..... 10 MΩ, ⩽ 70 pF

Maximum Input ..... 700V rms, 1000V Pk, or 2 x 10^7 volt/Hz, whichever is less.

OHMS (2-terminal or 4-terminal)

Ranges ..... 200Ω, 2 kΩ, 20 kΩ, 200 kΩ, 2 MΩ, 20 MΩ

Ranging ..... Fully Automatic or Manual

Resolution (Max) ..... 0.0005% F.S. (1 mΩ on 200Ω range) with 5-1/2 digit display

Table 1-2. 8860A Specifications (cont)

Accuracy ..... Using front panel zero, ±(% of input + no. of digits)

5-1/2 DIGIT DISPLAY

RANGE	24 HR 23°C ±1°C	90 DAY 18°C - 28°C	1 YR 18°C - 28°C
200	(0.008 + 4)	(0.012 + 4)	(0.015 + 4)
2k-200 kΩ	(0.006 + 2)	(0.01 + 2)	(0.013 + 2)
2M	(0.01 + 3)	(0.014 + 3)	(0.017 + 3)
20M	(0.07 + 3)	(0.09 + 3)	(0.10 + 3)

4-1/2 DIGIT DISPLAY

RANGE	90 DAY 18°C - 28°C	1 YR 18°C - 28°C
200 - 2 MΩ	(0.01 + 2)	(0.02 + 3)
20 MΩ	(0.1 + 2)	(0.14 + 3)

3-1/2 DIGIT DISPLAY

RANGE	1 YR 18°C - 28°C
200Ω - 2 MΩ	(0.1 + 1)
20 MΩ	(0.3 +1)

INPUT CHARACTERISTICS

RANGE	CURRENT THRU RX	OPEN CIRCUIT VOLTAGE
200	1 mA	6.0V MAX
2 kΩ	1 mA	
20 kΩ	100 uA	
200 kΩ	10 uA	
2 MΩ	1 uA	
20 MΩ	.1 uA	

Maximum Input ..... 300V DC or Peak AC

Ohms Settling Times

RANGE	5-1/2 and 4-1/2 DIGIT (TO .01% OF STEP)		3-1/2 DIGIT (TO .1% OF STEP)	
	NO FILTER	FILTER	NO FILTER	FILTER
200 - 20 kΩ	100 ms	<300 ms	<15 ms	<300 ms
200 kΩ		<1.1s		<800 ms
2m		<650 ms	<70 ms*	<500 ms
20m	<1.5s*	<6.8s	<600 ms*	<4.5s

*For these ranges the filter is recommended. This will reduce the effects of noise pick-up common to all high impedance measurements.

Table 1-2. 8860A Specifications (cont)

GENERAL

DISPLAY	RESOLUTION (% FS)	MAX READING/SEC	LINE FREQ. (HZ)	A/D INTEGRATE TIME (MS)
5-1/2	0.0005	2.5	50, 60	100
4-1/2	0.005	15 12	60 50	16-2/3 20
3-1/2*	0.05	30	50, 60	2

*Accessible through IEEE-488 or Calculating Controller options only.

Temperature ..... 0°C to +50°C operating; -40°C to +75°C non-operating.

Temperature Coefficient ..... ±0.1 x applicable accuracy specification per °C

Relative Humidity ..... ≤80% to +35°C; ≤70% to +50°C

Shock & Vibration ..... MIL-T - 28800B, class 4

Power ..... 100, 129, 220, 240V AC ±10%, 250VAC MAX., 50 Hz or 60 Hz

Size ..... 13.08 cm x 20.45 cm x 32.69 cm (HxWxL) (5.15 in x 8.05 in x 12.85 in) See Figure 1-1.

Weight ..... 3.39 kg (7.48 lbs.)

Protection Class 1 ..... Relates solely to insulating or grounding properties defined in IEC 348

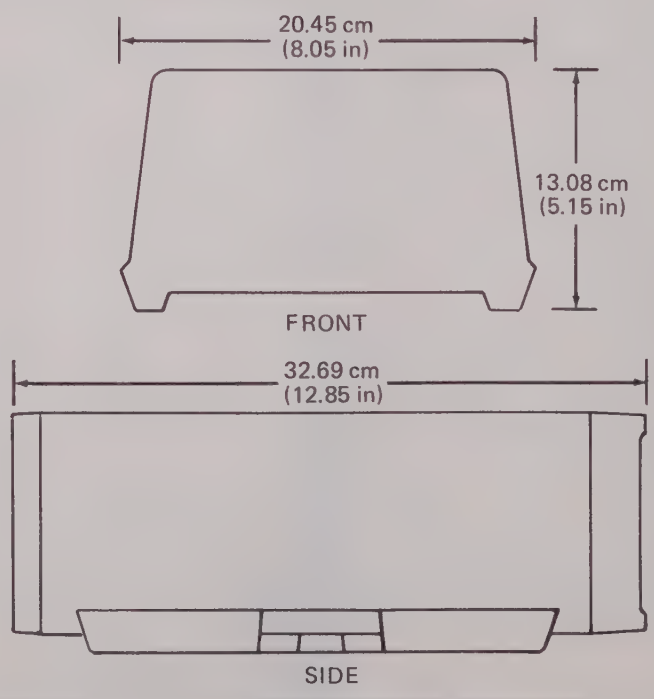

Figure 1-1. Outline Drawing

Section 2
Shipping and Service Information

2-1. SHIPPING INFORMATION

2-2. The 8860A is packaged and shipped in a foam-packed container. When you receive the 8860A, inspect it thoroughly for possible shipping damage. Special instructions for inspection and claims are included on the shipping container.

2-3. If reshipment is necessary, use the original container. If the original container is not available, order a new container from John Fluke Mfg. Co., Inc./P.O. Box 43210/Mountlake Terrace. WA 98043, telephone (206)774-2211.

2-4. SERVICE INFORMATION

2-5. Each John Fluke Model 8860A Digital Multimeter is warranted for a period of 1 year upon delivery to the original purchaser. The WARRANTY is located at the front of this manual.

2-6. Factory authorized calibration and service for each Fluke product is available at various worldwide locations. A complete list of these service centers is given in Appendix A. If requested, Fluke will provide an estimate before any work begins on instruments that are beyond the warranty period.

2-7. QUESTIONS/PROBLEMS

2-8. For any additional information, contact your nearest John Fluke Sales Representatives (see Appendix A), or the John Fluke Mfg. Co., Inc. at the address or telephone number given above.

WARNING

THE SERVICE INSTRUCTIONS CONTAINED IN THIS MANUAL ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN THE OPERATOR MANUAL UNLESS YOU ARE QUALIFIED TO DO SO.

Section 3
Access Procedures

WARNING

TO AVOID ELECTRICAL SHOCK HAZARDS WHEN THE TOP COVER IS REMOVED FROM THE 8860A, DO NOT WORK IN THE AREA OF THE POWER CONNECTOR IF LINE POWER IS APPLIED, AND DO NOT TOUCH THE INTERNAL GUARD COVER (FIGURE 6-1) WHEN VOLTAGES HIGHER THAN 30 VOLTS ARE APPLIED TO THE INPUT TERMINAL.

3-1. INTRODUCTION

3-2. This section of the manual contains the procedures required to access the 8860A line voltage selection switches and the calibration adjustments.

3-3. ACCESS

3-4. To access the line voltage switches and the calibration adjustments proceed as follows:

1. Remove line power from the instrument.

2. Turn the instrument over, bottom-side up.

3. Remove the four Phillips-head screws from the bottom cover.

4. Holding the top and bottom covers together, turn the instrument right-side up.

5. Using the case handle, pull the top cover up and off of the unit. See Figure 3-1. Both the front and rear panels should remain with the bottom half of the instrument.

6. Logically reverse this procedure to install the top cover. Carefully guide the front and rear panels into the top-cover slots.

CAUTION

Handle the unit carefully while the top cover is removed. The internal assemblies, and the front and rear panels are not secured to bottom case cover. They will fall out if the unit is turned over and they are not supported.

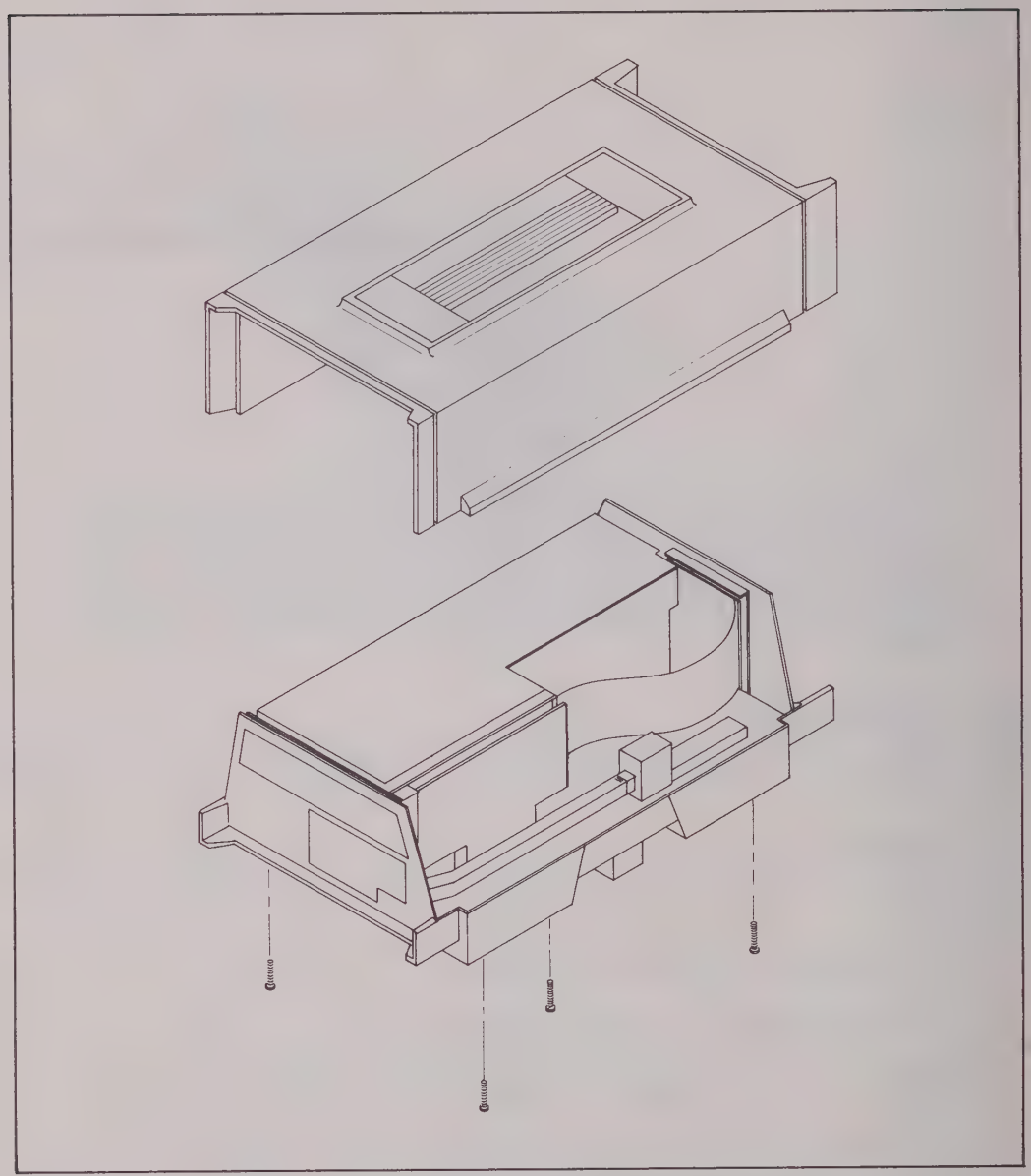

Figure 3-1. Switch and Calibration Adjustment Access

Section 4
General Maintenance

4-1. INTRODUCTION

4-2. This section of the manual contains the general maintenance procedures. These include cleaning instructions, line voltage selection, and fuse replacement. Do not perform any of these procedures when power is applied to the instrument.

4-3. CLEANING

4-4. Periodically clean the front panel using a soft cloth dampened with denatured alcohol or a mild solution of detergent and water. Use low pressure air (<20 psi) to clear dust from corners, crevices, and the interior of the 8860A.

WARNING

DO NOT USE AROMATIC HYDROCARBONS OR CHLORINATED SOLVENTS FOR CLEANING THE 8860A. THEY HAVE ADVERSE EFFECTS ON PLASTIC MATERIALS.

4-5. LINE VOLTAGE SELECTION

4-6. Input line voltage for the 8860A may be switch selected from one of four voltages (100, 120, 220, 240V ac ±10%) at frequencies of 50 or 60 hertz. Two slide switches are used to select the desired line voltage. One is used to select line frequency. The three switches are located inside the 8860A. Refer to the access procedures for instructions on cover removal. Figure 4-1 shows the possible switch settings. Set the switches, as required, using the slots for position indicators. When the line voltage settings are changed, install the correct fuse for the new setting.

4-7. FUSE REPLACEMENT

4-8. The fuse is located in the lower-left corner of the rear panel. When fuse replacement is necessary, remove the fuse-cap by turning it 1/8 of a turn counterclockwise with a screw driver. The fuse will pull out with the fuse-cap. Replace the fuse with one of the proper rating:

For 100 or 120V ac, use 1/4A Slo Blo, 250V
For 220 or 240V ac, use 1/8A Slo Blo, 250V

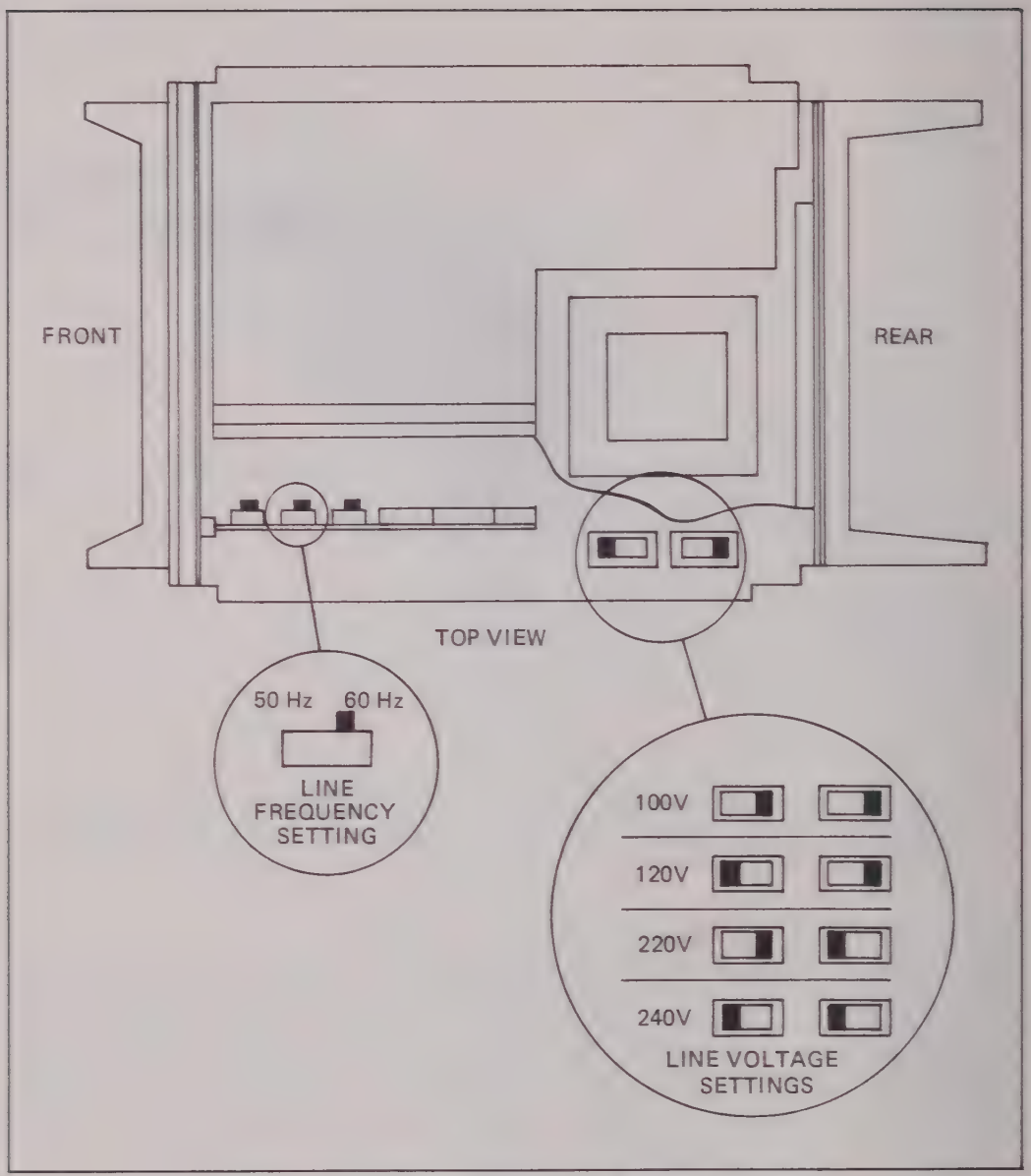

Figure 4-1. Line Voltage Switch Locations and Settings

Section 5
Performance Test

5-1. INTRODUCTION

5-2. The following paragraphs contain a performance verification test which compares the performance of the instrument to the specifications given in Section 1 of this manual. The test is recommended as an acceptance test when the unit is first received, and later as a calibration procedure to verify the 90-day accuracy specifications. It is also useful as an aid in troubleshooting.

5-3. Test equipment required for the performance test is listed earlier in Table 1-1. If the recommended equipment is not available, comparable instruments with equivalent specifications may be substituted. To ensure optimum results, the test must be performed at an ambient temperature of 18 to 28 degrees Celsius, with a relative humidity of less than 75%. Also, the instrument should be allowed to warm-up for a least 1-1 2 hours before starting the performance test.

5-4. If the instrument does not meet the performance test, troubleshooting, repair, and or calibration adjustment is indicated. Procedures for calibration adjustment are given later in this manual. Troubleshooting procedures are given in the Service Manual.

5-5. EQUIPMENT PREPARATION

5-6. Perform the following procedure prior to beginning the performance test.

1. Verify the instrument is set for the applicable line voltage using the procedure previously given.

2. Install the top cover.

3. Connect the instrument to the input line power.

4. Depress the POWER switch to apply line voltage to the instrument.

5. Allow the instrument to operate for at least 1-1/2 hours before beginning the test.

5-7. DC VOLTS TEST

5-8. Use the following procedure to verify the accuracy of the dc voltage ranges:

1. Place a shorting link between the HI and LO INPUT terminals.

2. Select the VDC function.

3. Zero the display be pressing the FCN and then the ZERO push buttons. Remove the shorting link.

4. Connect the DC Calibrator and the Voltage Divider to provide a voltage input to the HI and LO INPUT terminals.

NOTE

The Voltage Divider is not required for voltages above 1.0V dc.

5. Select the slow sample rate, 5-1/2 digit display.

6. Refer to Table 5-1. Sequentially select each of the voltage ranges shown in steps a through f and set the calibrator for the input specified for each range. Verify that the display reading is within the limits shown.

7. Disconnect the DC Calibrator from the 8860A INPUT terminals and install the shorting link.

8. Sequentially select the 2V and 20V ranges. The display should read .00000 and 0.0000 ±2 digits, respectively.

9. Remove the shorting link, and reconnect the DC Calibrator to the INPUT terminals.

10. Refer to Table 5-1 and verify that the display readings are correct using the range and input voltage given for steps g and h.

11. Select the fast sample rate, 4-1/2 digit display.

12. Using the range and input voltage specified in step i of Table 5-1, verify that the display reading is within the prescribed limits.

13. Disconnect the DC Calibrator from the 8860A INPUT terminals.

Table 5-1. DC Voltage Tests

STEP	RANGE	INPUT	DISPLAY READING 5-1/2 DIGITS	
			LOW	HIGH
a	200 mV	+ 100 mV	+99.989	+100.011
b	2V	+ .1 mV	+.00098	+.00102
c	2V	- .1 mV	-.00098	-.00102
d	2V	+ 1V	+.99989	+1.00011
e	2V	- 1V	-.99989	-1.00011
f	20V	+ 10V	+9.9989	+10.0011
g	200V	+ 100V	+99.989	+100.011
h	1000V	-1000V	-999.89	-1000.11*
			4-1/2 DIGITS	
i	2V	+ 1V	+ .9997	+1.0003

** If the 8860A display reading is greater than or equal to 1000.00, the display will flash.*

5-9. AC VOLTS TEST

5-10. Use the following procedure to verify the accuracy of the ac voltage ranges:

1. Select the VAC function.

2. Connect the AC Calibrator to provide a voltage input to the HI and LO INPUT terminals.

3. Select the slow sample rate, 5-1/2 digit display.

4. Refer to Table 5-2. Sequentially select each of the voltage ranges shown, and set the calibrator for the input specified for each range. Verify that the display reading is within the limits shown.

5. Set the AC Calibrator output to 0 volts or standby, and disconnect it from the 8860A INPUT terminals.

Table 5-2. AC Voltage Tests

RANGE	INPUT	8860A READING	
		LOW	HIGH
2V	.01V, 300 Hz	.00930	.01070
2V	1V, 300 Hz	.99780	1.00220
2V	1V, 100 kHz	.99000	1.01000
20V	10V, 100 kHz	9.9000	10.1000
200V	100V, 10 kHz	99.780	100.220
700V	500V, 10 kHz	498.60	501.40

5-11. OHMS TEST

5-12. Complete the following procedure to verify the accuracy of the ohms ranges:

1. Select the Ω4T function.

2. Select the slow sample rate, 5-1/2 digit display.

3. Enable the 8860A filter.

4. Connect a shorting link between the HI and LO Ω4T sense terminals and the INPUT LO terminal.

5. Zero the display by pressing the FCN and then the ZERO push buttons. Remove the shorting link.

6. Connect the Resistor Decade, using four-terminal connections (current and sense leads), to the INPUT and Ω4T sense terminals on the 8860A.

7. Refer to Table 5-3. Sequentially select each of the voltage ranges shown, and set the Resistor Decade for the specified input. Verify that the display reading is within the limits shown.

8. Disconnect the Resistor Decade from the 8860A.

Table 5-3. Ohms Test

RANGE	INPUT	8860A READING	
		LOW	HIGH
2K	1K ohms	.99988	1.00012
20K	10K ohms	9.9988	10.0012
200K	100K ohms	99.988	100.012
2M	1M ohms	.99983	1.00017
20M	10M ohms	9.9910	10.0090

5-13. DC EXTERNAL REFERENCE TEST (OPTION -007)

5-14. Use the following procedure to verify the accuracy of the DC External Reference, Option -007:

1. Complete the equipment connections shown in Figure 5-1.

2. On the 8860A, select VDC, 2V range, EXT REF, and the 5-1/2 digit display.

3. Set the DC Calibrator for a 10V dc output, and adjust the Voltage Divider for a 1.0V dc input to the 8860A.

4. Read the display. It should read +1.00000 ±16 digits.

5. Reverse the connections at the External Reference Terminals. The display should read -1.00000 ±16 digits.

6. Reverse the connections at the input to the Voltage Divider. The display should read +1.00000 ±16 digits.

7. Reverse the connections at the External Reference terminals. The display should read -100000 ±16 digits.

8. Set the DC Calibrator for a 1.0V dc output. After settling, the display should read -1.00000 ±70 digits.

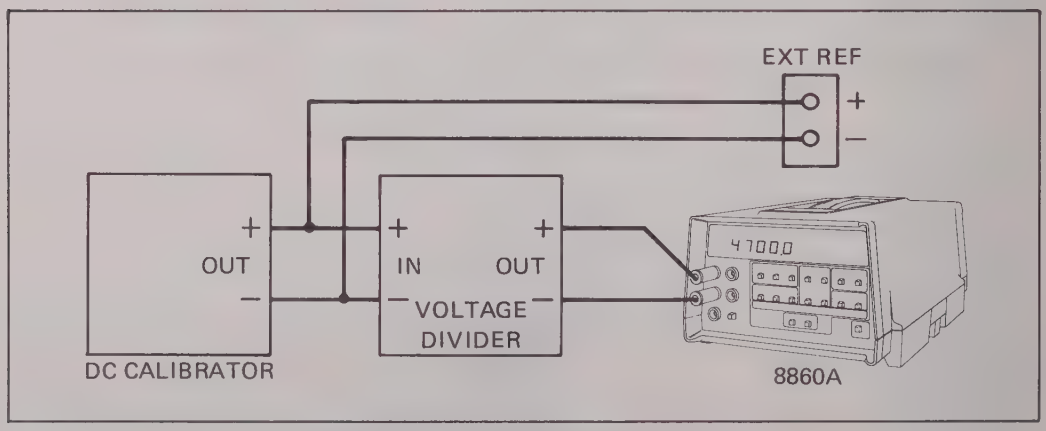

Figure 5-1. DC External Reference Test

Section 6
Calibration Adjustments

6-1. INTRODUCTION

6-2. The calibration adjustment procedures given in the following paragraphs should be performed after repair of the 8860A and/or when the unit fails the performance-test requirements. If the unit will not respond to, or meet the limits of the adjustment procedures, troubleshooting and repair are indicated. Equipment required for the calibration adjustments is listed earlier in Table 1-1.

6-3. All calibration adjustments are accessible when the top cover is removed from the 8860A. The locations of the test points, and adjustments that must be accessed to complete the calibration adjustment procedures are printed on the instrument guard cover shown in Figure 6-1.

6-4. To ensure optimum results, the calibration adjustments must be performed at an ambient temperature of 22 to 24 degrees Celsius, with a relative humidity of less than 75%. Also the unit should be allowed to warm-up for at least 1-1/2 hours before starting the adjustment procedures.

6-5. Instrument accuracies during the first 24 hours, 90 days, and 1 year after calibration are given in the instrument specification. Adjust the calibration cycle accordingly.

6-6. INITIAL PROCEDURE

6-7. Complete the following procedure before attempting to make any of the calibration adjustments:

1. Remove the top cover from the 8860A. See Access Procedure in Section 3.

2. Set the top cover back on the unit.

3. Connect the 8860A to line power and set the POWER switch to on.

4. Allow the unit to stabilize for 1-1/2 hours before proceeding with the adjustment procedures.

6-8. ADJUSTMENT PROCEDURES

6-9. Complete the adjustment procedures in sequence. Refer to Figure 6-1 for all test point and adjustment locations. Specified inputs assume the use of the appropriate equipment listed earlier in Table 1-1. Use the Voltage Divider for all dc voltage inputs that are less than 2V dc.

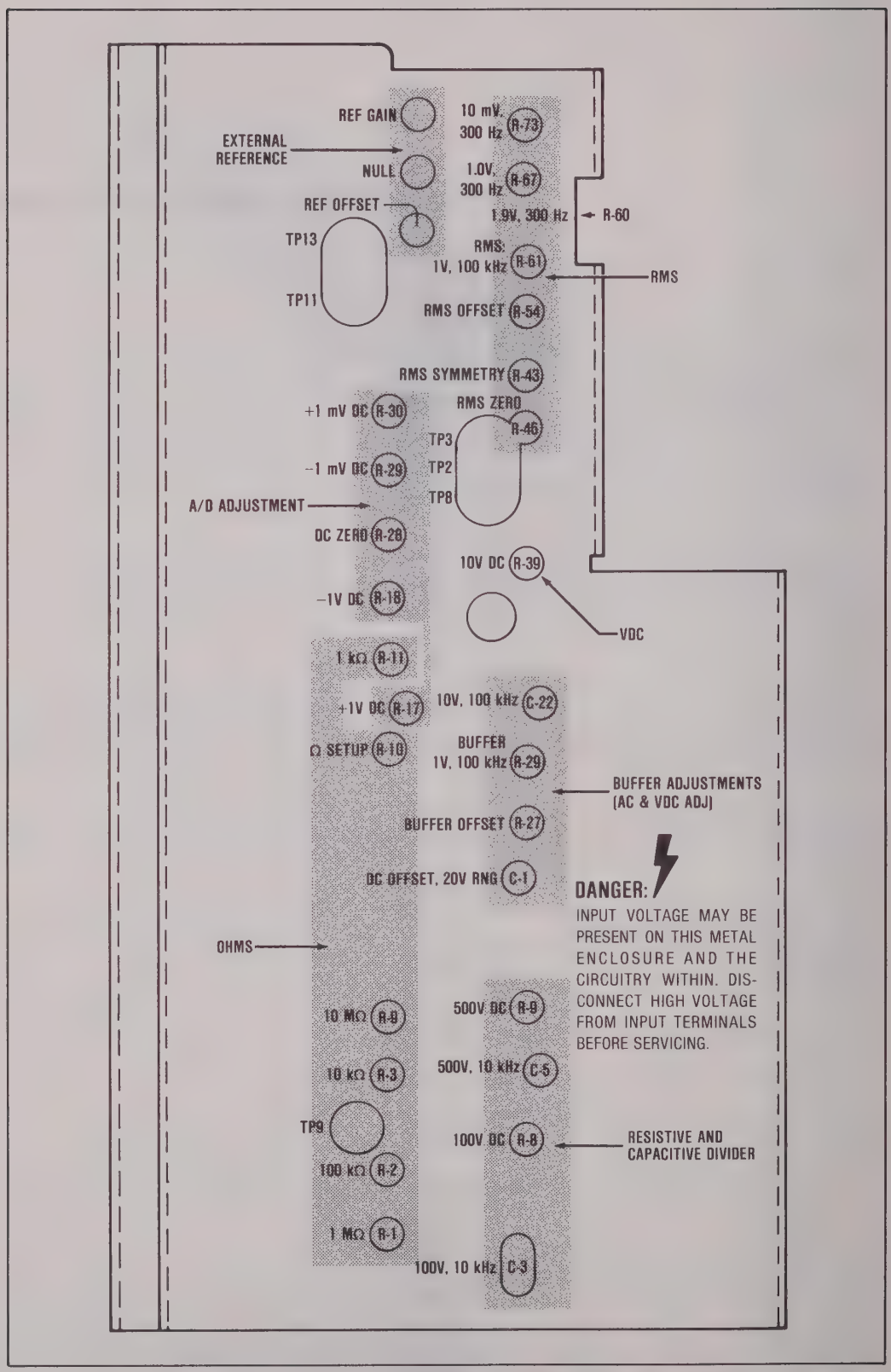

Figure 6-1. Test Point and Calibrations Adjustment Locations

6-10. DC Offset

6-11. Use the following procedure to calibrate DC offset:

1. Connect a shorting wire between the HI and LO INPUT terminals.

2. Select VDC and the 2V range.

3. Set the +1 mV DC (R30) and the -1 mV DC (R29) adjustments fully clockwise.

4. Adjust DC ZERO (R28) until the sign flashes + and - with equal frequency. Ignore the numeric reading.

5. Remove the short and apply +1.0 mV dc to the input. Adjust R30, +1 mV DC, until the display reads +.00100, with occasional readings of +.00099.

6. Apply a -1.0 mV dc input to the 8860A. Adjust R29, -1 mV DC, until the display reads -.00100, with occasional readings of -.00099.

7. Connect a shorting wire between the HI and LO INPUT terminals.

8. Select the 20V range on the 8860A.

9. Adjust DC OFFSET, 20V RNG, (C1) for a display reading of ±0.0000.

10. Select the 2V range and repeat steps 4-9 until no further corrections are required.

6-12. VDC Function and Ranges

6-13. The following procedure is used to calibrate the VDC ranges (VDC function and 2V range still selected):

1. Apply +1.0V dc and adjust +1 VDC (R17) until the display reads +1.00000, with occasional readings of +.99999.

2. Apply -1.0V dc and adjust -1 VDC (R18) until the display reads -1.00000, with occasional readings of -.99999.

3. Apply +1.9V dc and verify that the display reads +1.90000 ±4 digits.

4. Apply -1.9V dc and verify that the display reads -1.90000 ±4 digits.

5. Select the 200V range.

6. Connect a DC Calibrator to the HI and LO INPUT terminals of the 8860A.

7. Adjust the DC Calibrator to +100VDC.

8. Adjust the 100VDC resistor (R8) for a display of +100.000.

9. Select the 1000V range on the 8860A.

10. Adjust the DC Calibrator to +500V.

11. Adjust the 500 VDC resistor (R9) for a display of +500.00.

12. Repeat steps 5-11 until no further adjustments are required.

13. Adjust the DC Calibrator to 10V and select the 20V dc range on the 8860A.

14. Adjust 10 VDC (R39) for a display of +10.0000.

15. Select the 1000V range on the 8860A; connect the DC Calibrator to the 8860A and increase the input signal to +1000.00V. The display should read +1000.00 ±3 digits.

16. Apply -1000V dc to the input. The display should read -1000.00 ±3 digits. Decrease the calibrator output to a safe level, less than 30V dc, and disconnect it from the 8860A INPUT terminals.

17. Short the input with a shorting link and select the 200 mV dc range. Press FCN followed by ZERO on the front panel of the 8860A.

18. Using the Voltage Divider, apply +100.0 mV dc to the input. The reading should be +100.000 ±2 digits.

19. Apply -100.0 mV dc to the input. The reading should be -100.000 ±2 digits.

6-14. AC/RMS Offset Adjustments

6-15. The following procedure is used to initially zero the AC/DC buffer, and the linear components on the RMS converter.

1. Connect a shorting link between the HI and LO INPUT terminals of the 8860A.

2. Select VAC and the 20V range on the 8860A.

3. Connect a DC Voltmeter between TP5 and the LO INPUT terminal.

4. Adjust BUFFER OFFSET (R27) for a DC Voltmeter reading of 0.0 ±0.01 mV dc.

5. Connect the DC Voltmeter between TP2 and LO INPUT terminal.

6. Adjust RMS OFFSET (R54) for a DC Voltmeter reading of 0.0 ±0.01 mV dc.

7. Connect a scope and a 10X scope probe to TP3. Use the LO INPUT terminal for the ground connection.

8. Set the scope to 200 mV/division sensitivity, 1 ms/division horizontal sweep, and DC coupling on the input amplifier.

9. Zero the scope, and then adjust RMS ZERO (R46) for a 0V dc trace on the scope. (There is typically ±100 mV of ac noise on the trace.)

10. Repeat step 5 and verify that the voltage reading is 0.0 ±.01 mV dc. If the reading is not correct, repeats steps 6 through 9.

6-16. Buffer Frequency Response

6-17. The following procedure is used to adjust the frequency response of the buffer.

1. Connect an AC Calibrator to the HI and LO INPUT terminals of the 8860A.

2. Select DC coupled VAC and the 2V range on the 8860A.

3. Connect an AC Voltmeter between the input terminals of the 8860A.

4. Adjust the AC Calibrator to 1.0V, 100 kHz, and record the reading on the AC Voltmeter.

5. Connect the AC Voltmeter between TP5 and LO INPUT terminal.

6. Adjust BUFFER: 1V, 100 kHz (R29) for an AC Voltmeter reading that is within 0.01% of the reading recorded in step 4.

7. Disconnect the AC Calibrator from the 8860A.

6-18. RMS Converter

6-19. The following procedure is used to adjust the scale factor and linearity of the RMS converter.

1. Select DC coupled VAC and the 2V range on the 8860A.

2. Connect a DC Calibrator to the HI and LO INPUT terminals on the 8860A.

3. Adjust the DC Calibrator to +1.0V dc.

4. Record the reading on the 8860A.

5. Apply –1.0V dc to the 8860A. Monitor the display.

6. Adjust RMS SYMMETRY (R43) until the display reads the value recorded in step 4.

7. Select VAC and the 2V range on the 8860A.

8. Disconnect the DC Calibrator, and connect an AC Calibrator to the HI and LO terminals.

9. Adjust the AC Calibrator to 1.0V, 300 Hz.

10. Adjust the 1.0V, 300 Hz resistor (R67) for an 8860A display reading of 1.00000 ±5 digits.

11. Adjust the AC Calibrator for an output of 10 mV, 300 Hz.

12. Adjust the 10 mV, 300 Hz resistor (R73) for an 8860A display reading of 0.01000 ±1 digit.

13. Adjust the AC Calibrator for an output of 1.9V, 300 Hz.

14. Adjust the 1.9V, 300 Hz resistor (R60) for a display reading of 1.90000 ±10 digits.

15. Repeat steps 9-14 until no further corrections are required.

16. Adjust the AC Calibrator to 1.0V, 100 kHz.

17. Adjust the RMS: 1V, 100 kHz resistor (R61) for an 8860A display reading of 1.00000 ±5 digits.

18. Select the 200 mV range. Apply 1 mV, 300 Hz. The reading must be within 40 digits of nominal.

19. Select the 20V range. Apply 100 mV, 300 Hz. The reading must be within 40 digits of nominal.

6-20. AC Divider Response

6-21. The following procedure is used to calibrate the AC dividers of the 8860A.

1. Select VAC and the 200V range.

2. Connect an AC Calibrator to the HI and LO INPUT terminals of the 8860A.

3. Apply 100V, 10 kHz to the 8860A.

4. Adjust the 100V, 10 kHz capacitor (C3) for an 8860A reading of 100.000 ±10 digits.

5. Select the 700V range on the 8860A.

6. Adjust the AC Calibrator to 500V, 10 kHz.

7. Adjust the 500V, 10 kHz capacitor (C5) for an 8860A reading of 500.00 ±10 digits.

8. Repeat steps 3-7 until no further corrections are required.

9. Apply 10V, 100 kHz to the input of the 8860A.

10. Adjust the 10V, 100 kHz capacitor (C22) for a display reading of between 9.9800 and 10.0200, nominally 10.0000.

11. Apply 100 mV, 100 kHz to the 8860A.

12. Select the 200 mV range on the 8860A. The reading should be 100.000 ±900 digits.

6-22. Ohms Converter

6-23. Use the following procedure to calibrate the Ohms Converter:

1. Set the 8860A to the Ω4T function, and enable the FILTER and AUTORANGE.

2. Connect the Decade Resistor to the 8860A using four-terminal connections.

3. Refer to Table 6-1, and set the Decade Resistor to the input values given for steps a and b. Make the adjustment shown for each input to obtain the specified display limits.

4. Repeat steps a and b for convergence.

5. Perform steps c through f as shown in Table 6-1.

Table 6-1. Ohms Converter Adjustments

STEP	INPUT RESISTANCE	ADJUST	DISPLAY LIMITS
a	10. MΩ	Ohms Setup (R10)	9.9960 to 10.0040
b	1.0 kΩ	1 kΩ (R11)	.99999 to 1.00001
c	10.0 kΩ	10 kΩ (R3)	9.9999 to 10.0001
d	100.0 kΩ	100 kΩ (R2)	99.999 to 100.001
e	1.0 MΩ	1 MΩ (R1)	.99999 to 1.00001
f	10. MΩ	10 MΩ (R9)	9.9995 to 10.0005

6-24. DC External Reference

6-25. Use the following procedure to calibrate the DC External Reference, Option -007. Complete the Calibration Adjustments for the basic 8860A before performing this procedure.

1. Center each of the following external Reference Adjustments: REF GAIN (R1), NULL (R4), REF OFFSET (R5).

2. Complete the equipment connections shown in Figure 6-2A.

3. Use the DC Voltmeter to measure the voltage between TP13 and the INPUT LO Terminal.

4. Adjust REF OFFSET (R5) for a DC Voltmeter reading of 0.0 ±5 uV dc.

5. Modify the equipment connections to conform with those shown in Figure 6-2B. Set the DC Calibrator for a +10.0V dc output.

6. Adjust NULL (R4) until the voltage at TP13 reads 0.0 ±5 uV dc.

7. Modify the equipment connections to conform with those shown in Figure 6-2C.

8. Adjust REF GAIN (R1) for a DC Voltmeter reading of –1.00000 ±1 digit at TP13.

9. Repeat steps 2 through 8 of this procedure until all requirements are met without adjustment.

10. Modify the equipment connections to conform with those given in Figure 6-2D.

11. Set the 8860A as follows: VDC, 2V range, EXT REF enabled.

12. Set the Voltage Divider for a 1.0V dc output.

13. Adjust REF GAIN (R1) for a display reading of +1.00000 ±1 digit.

14. Press EXT REF to turn off the EXT REF light.

15. Connect the DC Voltmeter between TP13 and the INPUT LO terminal.

16. Repeat steps 5 and 6 of this procedure.

17. Disconnect all equipment.

18. Verify operation of the active filter as follows:

    a. Connect an AC Voltmeter between TP13 and INPUT LO.

    b. Set the 8860A to: VDC, 2V range, and EXT REF light off.

    c. Using the AC Calibrator, apply a 10V, 60 Hz signal between EXT REF terminals. Connect EXT REF (–) to the INPUT LO terminal.

    d. The AC Voltmeter should read less than 0.010V ac.

    e. Disconnect all equipment and install the cover on the 8860A.

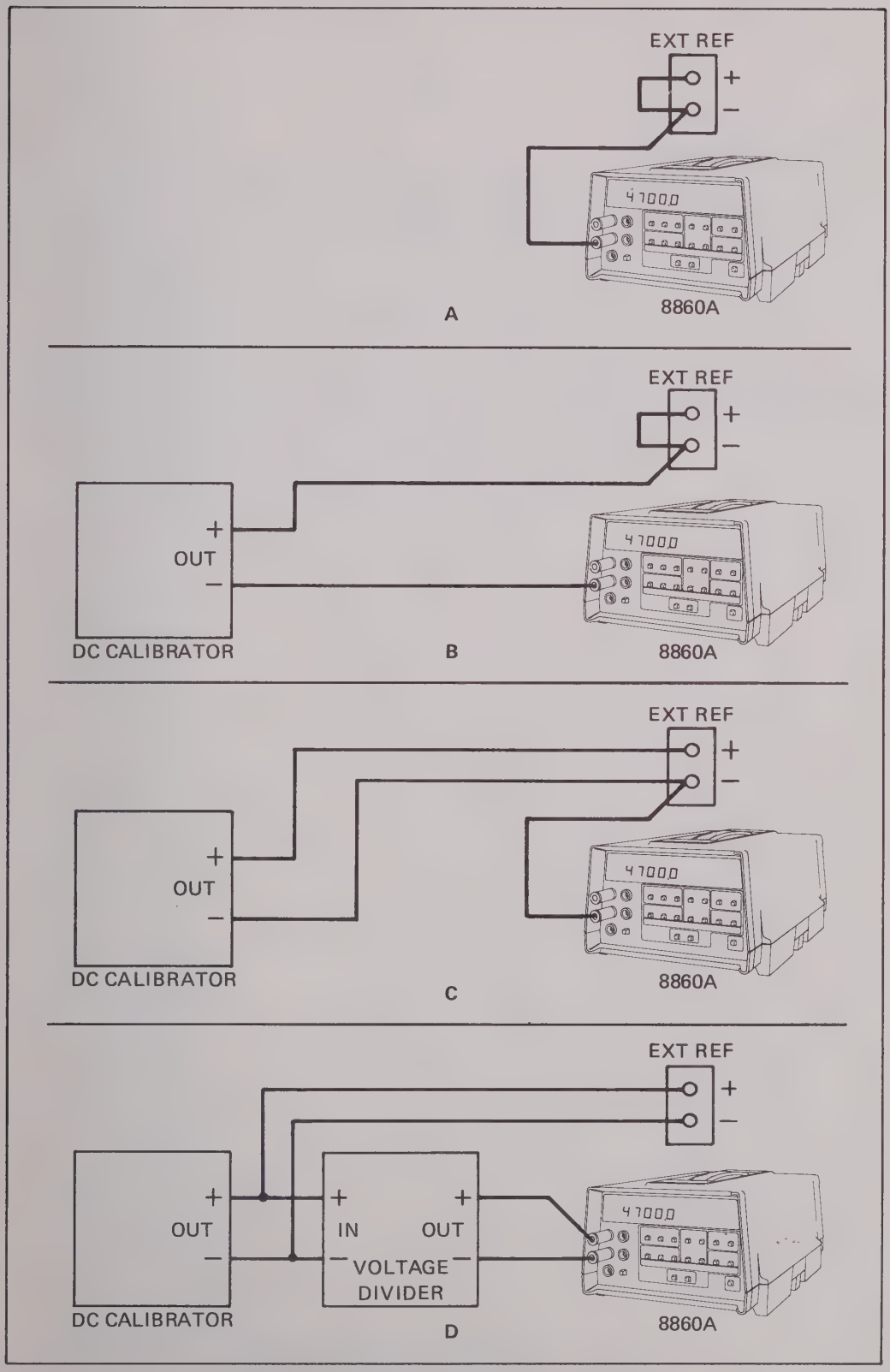

Figure 6-2. EXT REF Equipment Connections

Appendix A
Fluke Sales and Service Centers

Authorized Fluke Sales Representatives and Service Centers are available at various worldwide locations. Table A-1 and A-2 provide a complete list of service centers. The Fluke Sales Representatives are listed in Tables A-3 and A-4.

Table A-1. Fluke Technical Service Centers - U.S. and Canada

UNITED STATES

CA, Burbank
Fluke Technical Center
2020 N. Lincoln Street
Burbank, CA 91504
(213) 849-4641

CA, Santa Clara
Fluke Technical Center
2300 Walsh Avenue
Santa Clara, CA 95050
(408) 985-1200

CO, Denver
Fluke Technical Center
1980 S. Quebec Street, Unit 4
Denver, CO 80231
(303) 750-1228

FL, Orlando
Fluke Technical Center
940 N. Fern Creek Avenue
Orlando, FL 32803
(305) 896-2296

IL, Rolling Meadows
Fluke Technical Center
1400 Hicks Road
Rolling Meadows, IL 60008
(312) 398-5800

MA, Waltham
Fluke Technical Center
244 Second Avenue
Waltham, MA 02154
(617) 890-1604

MD, Rockville
Fluke Technical Center
5640 Fishers Lane
Rockville, MD 20852
(301) 770-1576

MN, Apple Valley
Fluke Technical Center
7373 West 147th Street, Suite 196
Apple Valley, MN 55124
(612) 432-9400

NC, Greensboro
Fluke Technical Center
1310 Beaman Place
Greensboro, NC 27408
(919) 273-1918

NJ, Paramus
Fluke Technical Center
West 75th Century Road
Paramus, NJ 07652
(210) 262-9550

TX, Dallas
Fluke Technical Center
14400 Midway Road
Dallas, TX 75240
(214) 233-9945

WA, Mountlake Terrace
John Fluke Mfg. Co., Inc.
21707 66th Avenue W., Suite 1
Mountlake Terrace, WA 98043
(206) 774-2206

CANADA

ALB, Calgary
Allan Crawford Assoc., Ltd.
1935 30th Avenue N.E. #14
Calgary, ALB T2E 6Z5
(403) 230-1341

ONT, Mississauga
Allan Crawford Assoc., Ltd.
6503 Northam Drive
Mississauga, ONT L4V 1J5
(416) 678-1500

QUE, St. Laurent
Allan Crawford Assoc., Ltd.
7018 Cote de Liesse
St. Laurent, QUE H4T 1E7
(514) 731-8564

Table A-2. Fluke Technical Service Centers - International

ARGENTINA
Fluke Latin American
Service Headquarters
Virrey del Pino 4071
Buenos Aries, Argentina
Tel: 523185

AUSTRALIA
Elmeasco Instrument Pty Ltd.
P.O. Box 30
Concord, N.S.W.
Australia 2137
Tel: (02) 736-2888

AUSTRIA
Walter Rekirsch
Elektronische Gerate GmbH & Co.
Vertriebs-KG.
Liechtensteinstrasse 97/6
A-1090 Vienna, Austria
Tel: 09-43-222-347646

BELGIUM
Fluke (Belgium)S.A./N.V.
6, Rue de Geneve
1140 Brussels, Belgium
Tel: 09-32-2-2164090

BRAZIL
Arotec S.A.
Industria e Comercio
Av. Pacaembu 811
01234 Sao Paulo S.P., Brazil
Tel: 826-2266

CHILE
Intronica Chile Ltda.
Casilla 16228
Santiago 9, Chile
Tel: 44940

COLOMBIA
Coasin Ltda.
Carrera 13, # 37-37, Of. 407
Ap. Aero 29583
Bogota DE, Colombia
Tel: 285-0230

DENMARK
Tage Olsen A/S
Ballerup Byvej 222
DK-2750 Ballerup
Denmark
Tel: (01) 2-65 81 11

ECUADOR
Proteco Coasin Cia., Ltda.
Edificia "Jerico"
Ave. 12 de Octubre #2285y
Ave, Orellana (Planta Baja)
Quito, Ecuador
Tel: 526759

EGYPT
Lotus Engineering Organisation
P.O. Box 1252
Cairo, Egypt
Tel: 71617

FINLAND
Oy Findip AB
Teollisuustie 7
02700 Kauniainen
Finland
Tel: 09-358-0-502255

FRANCE
M.B. Electronique S.A.
Rue Fourny
ZAC de BUC
B.P. #31
78530 BUC, France
Tel: 09-33-1-9568131

GREECE
Hellenic Scientific
Representations Ltd.
11, Vrassida Street
Athens 615, Greece
Tel: 09-30-1-711140

HONG KONG
Gilman Industrial Bldg., 9F
107-109 Wai Yip Street
Kwun Tong
Kowloon, Hong Kong
Tel: 3-427144

Table A-2. Fluke Technical Service Centers - International (cont)

INDIA
Hinditron Services Pvt. Ltd.
"Hinditron House"
412 Raj Mahal Vilas Extension
Bangalore 560 006, India
Tel: 33139

Hinditron Services Pvt. Ltd.
69 A.L. Jagmohandas Marg
Bombay 400 006, India
Tel: 365344

INDONESIA
P.T. Dwi Tunggal Jaya Sakti
Sangga Buana Bldg., 1st Floor
J1. Senen Raya 44, P.O. Box 4435
Jakarta, Indonesia
Tel: 376608

IRAN
Irantronics Company Ltd.
20 Salm Road
Roosevelt Avenue
Tehran, Iran
Tel: 828294/831564

ISRAEL
R.D.T. Electronics Engineering Ltd.
P.O. Box 75
46, Sokolov Street
Ramat Hasharon 47235
Israel
Tel: 09-972-3-483211

ITALY
Sistrel S.p.A.
Via Timavo 66
20099 Sesto S. Giovanni (Milan)
Italy
Tel: 09-39-2-2476693

Sistrel S.P.A.
Via Guiseppe Armellini #37
00143 Rome, Italy
Tel: 09-39-6-5915551

JAPAN
John Fluke Mfg. Co., Inc.
Japan Branch
1 Higashikata-machi
Midori-ku
Yokohama 226, Japan
Tel: (045) 473-5425

KOREA
Electro-Science Korea Co.
C.P.O. Box 8446
Room 1201 Bowon Bldg.
490 Chongro - 5 Ka
Chongro-ku
Seoul, Korea
Tel: 261-7702

MALASIA
O'Connor's (Malaysia) SDN. BHD.
P.O. Box 91
Petaling Jaya, Selangor
West Malaysia
Tel: 51563

MEXICO
C.J. Christensen S.A. De C.V.
Melchor Ocampo 150-8
Mexico 4 D.F., Mexico
Tel: (905) 535-2258

NETHERLANDS
Fluke (Nederland) B.V.
P.O. Box 5053
5004 EB Tilburg
The Netherlands
Tel: (013) 673973

NEW ZEALAND
W & K McLean Ltd.
P.O. Box 18065
Glen Innes
Auchland, New Zealand
Tel: 587-037

NORWAY
Morgenstierne & Co. A/A
Konghellegate 3
P.O. Box 6688, Rodelokka
Oslo 5, Norway
Tel: 09-47-2-356110

PAKISTAN
Pak International Operations
505 Mohammadi House
1.1. Chundrigar Road
Katrachi-2 Pakistan
Tel: 221127/239052

PERU
Importaciones Y Representaciones Electronicas S.A.
Avda. Franklin D. Roosevelt 105
Lima 1, Peru
Tel: 288650

PORTUGAL
Equipamentos de Laboratorio, Ltda
P.O. Box 1100
Lisbon 1002, Portugal
Tel: 09-351-1-578936/547512

REPUBLIC OF SINGAPORE
Rank O'Connor's (PTE) Ltd.
98 Pasir Panjang Road
Singapore 0511
Republic of Singapore
Tel: 637944

REPUBLIC OF SOUTH AFRICA
Fluke S.A. (Pty) Ltd.
P.O. Box 39797
Bramley 2018
Republic of South Africa
Tel: (011) 786-3170

SPAIN
Hispano Electronica S.A.
Apartado de Correos 48
Alcorcon (Madrid)
Spain
Tel: 09-3416194108

SWEDEN
Teleinstrument AB
P.O. Box 490
S-162 Vallingby 4
Sweden
Tel: 09-46-8-380370

SWITZERLAND
Traco Electronic AG
Jenatschstrasse 1
8002 Zurich
Switzerland
Tel: 09-41-1-2010711

TAIWAN
CCT Associates, Inc.
P.O. Box 24209
Taipei, Taiwan
Republic of China
Tel: (02) 391-6894/393-5760

THAILAND
Dynamic Supply Engineering R.O.P.
56 Ekamai, Sukhumvit 63
Bangkok-11, Thailand
Tel: 914434/928532

TURKEY
Erkman Electronik Aletler
Ticaret Anonim Sirketi
Necatiby Cad 92/3
Karakoy, Istanbul, Turkey
Tel: 09-44-1-5461

UNITED KINGDOM
Fluke International Corp. - UK
Colonial Way
Watford, Herts. WD24TT
United Kingdom
Tel: 09-4492340511

URUGUAY
Coasin Uruguaya S.R.L.
Edifico Ciudadela
Sarandi 690 D. Esc. 109
Casilla de Correos 1400
Correo Central
Montevideo, Uruguay
Tel: 917978

VENEZUELA
Coasin C.A.
Apdo. Postal 50939
Sabana Grande # 1
Caracas 105, Venezuela
Tel: 782-9109

WEST GERMANY
Fluke (Deutschland) GmbH
Krausstrasse 32
8045 Ismaning
West Germany
Tel: (089) 96251

Customers in the following countries: Bulgaria, Czechoslovakia, Hungary, Poland, Romania, U.S.S.R., and Yugoslavia, contact: Amtest Associates Ltd., P.O. Box 55, Addlestone, Surrey, KT 15 1DU, England, Tel. (0932) 52121

Table A-3. Sales Representatives - U.S. and Canada

UNITED STATES

AK, Anchorage
Harry Lang & Associates
1371 Hillcrest Drive #303
Anchorage, AK 99503
(907) 279-5741

AL, Huntsville
John Fluke Mfg. Co., Inc.
3322 Memorial Parkway
Huntsville, AL 35807
(205) 881-6220
(404) 321-0980 (Atlanta)

AZ, Tempe
John Fluke Mfg. Co., Inc.
2125 S. 48th Street, Suite 104
Tempe, AZ 85285
(602) 967-8724

CA, Los Angeles
John Fluke Mfg. Co., Inc.
20902 S. Bonita Street
Carson, CA 90746
(213) 538-3900

CA, Santa Clara
John Fluke Mfg. Co., Inc.
2300 Walsh Avenue
Santa Clara, CA 95050
(408) 244-1505

CA, Tustin
John Fluke Mfg. Co., Inc.
15445 Red Hill Avenue, Suite F
Tustin, CA 92680
(714) 838-8863
(714) 226-1254 (San Diego)

CO, Denver
John Fluke Mfg. Co., Inc.
1980 S. Quebec, #4
Denver, CO 80231
(303) 750-1222

CT, Hartford
John Fluke Mfg. Co., Inc.
124 Hebron Avenue
Glastonbury, CT 06033
(203) 633-0777

FL, Orlando
John Fluke Mfg. Co., Inc.
940 N. Fern Creek Avenue
Orlando, FL 32803
(305) 896-4881

HI, Honolulu
EMC Corporation
2979 Ualena Street
Honolulu, HI 96819
(808) 847-1138

IA, Iowa City
John Fluke Mfg. Co., Inc.
1027 Hollywood Blvd., Suite 309
Iowa City, IA 52240
(319) 354-2811

IL, Chicago
John Fluke Mfg. Co., Inc.
4300 Lincoln, Unit K
Rolling Meadows, IL 60008
(312) 398-0850

IN, Indianapolis
John Fluke Mfg. Co., Inc.
5610 Crawfordsville Road,
Suite 802
Indianapolis, IN 46224
(317) 244-2456

LA, Metairie
John Fluke Mfg. Co., Inc.
2700 Kingman Street, Suite 103
Metairie, LA 70002
(504) 455-0814

MA, Waltham
John Fluke Mfg. Co., Inc.
244 Second Avenue
Waltham, MA 02154
(617) 890-1600

MD, Baltimore
John Fluke Mfg. Co., Inc.
5640 Fishers Lane
Rockville, MD 20852
(301) 770-1570
(301) 792-7060 (Baltimore)

MI, Detroit
John Fluke Mfg. Co., Inc.
13955 Farmington Road
Livonia, MI 48154
(313) 522-9140

MN, Minneapolis
John Fluke Mfg. Co., Inc.
7373 W. 147th Street, Suite 196
Apple Valley, MN 55124
(612) 432-9400

MO, Kansas City
John Fluke Mfg. Co., Inc.
4406 Chouteau Traffic Way
Kansas City, MO 64117
(816) 454-5836

MO, St. Louis
John Fluke Mfg. Co., Inc.
300 Brookes Drive, Suite 100
Hazelwood, MO 63042
(314) 731-3388

NC, Greensboro
John Fluke Mfg. Co., Inc.
1310 Beaman Place
Greensboro, NC 27408
(919) 273-1918

NJ, Paramus
John Fluke Mfg. Co., Inc.
West 75 Century Road
Paramus, NJ 07625
(201) 262-9550

NM, Albuquerque
John Fluke Mfg. Co., Inc.
1108 Alvarado Drive N.E.
Albuquerque, NM 87110
(505) 265-8431

NY, Rochester
John Fluke Mfg. Co., Inc.
4515 Culver Road
Rochester, NY 14622
(716) 266-1400

OH, Cleveland
John Fluke Mfg. Co., Inc.
7830 Freeway Circle
Middleburg Heights, OH 44130
(216) 234-4540

OH, Dayton
John Fluke Mfg. Co., Inc.
4756 Fishburg Road
Dayton, OH 45424
(513) 233-2238

OR, Portland
John Fluke Mfg. Co., Inc.
18360 S.W. Springfield Lane
Aloha, OR 97006
(502) 642-1342

PA, Philadelphia
John Fluke Mfg. Co., Inc.
1010 W. 8th Avenue, Suite H
King of Prussia, PA 19406
(215) 265-4040
(412) 261-5171 (Pittsburgh)

TX, Austin
John Fluke Mfg. Co., Inc.
111 W. Anderson Lane, Suite 213
Austin, TX 78752
(512) 478-9901

TX, Dallas
John Fluke Mfg. Co., Inc.
14400 Midway Road
Dallas, TX 75243
(214) 233-9990

TX, Houston
John Fluke Mfg. Co., Inc.
1014 Wirt Road, Suite 270
Houston, TX 77055
(713) 683-7913
(512) 222-2726 (San Antonio)

UT, Salt Lake City
John Fluke Mfg. Co., Inc.
782 E. 8325 South
Sandy, UT 84070
(801) 566-4864

WA, Kennewick
John Fluke Mfg. Co., Inc.
3613 W. 16th Place #C
Kennewick, WA 99336

WA, Seattle
John Fluke Mfg. Co., Inc.
975 Industry Drive
Seattle, WA 98188
(206) 575-3765

For more information on Fluke products or Sales Offices you may dial (800) 426-0361 toll free in most of U.S. From Alaska, Hawaii, Washington, or Canada phone (206) 774-2481. From other countries phone (206) 774-2398.

Table A-3. Sales Representatives - U.S. and Canada (cont)

CANADA

ALB, Calgary
Allan Crawford Assoc., Ltd.
1935 30th Avenue N.E., #14
Calgary, ALB T2E 6Z5
Tel: (403) 230-1341

BC, North Vancouver
Allan Crawford Assoc., Ltd
3795 William Street
Burnaby, BC Y5C 3H3
Tel: (604) 294-1326

NS, Halifax
Allan Crawford Assoc., Ltd
Townsend Place, Suite 201
800 Windmill Road
Burnside Industrial Park
Dartmounth, NS B3B 1L1
Tel: (902) 469-7865

ONT, Ottawa
Allan Crawford Assoc., Ltd
1299 Richmond Road
Ottawa, ONT K2B 7Y4
Tel: (613) 829-9651

ONT, Toronto
Allan Crawford Assoc., Ltd.
6503 Northam Drive
Mississauga, ONT L4V 1J5
Tel: (416) 678-1500

QUE, Montreal
Allan Crawford Assoc., Ltd.
7018 Cote de Liesse
St. Laurent, QUE H4T 1E7
Tel: (514) 731-8564

For Canadian areas not listed, contact the office nearest you or Allan Crawford Assoc. Ltd., Mississauga (Toronto), Ontario.

Table A-4. Sales Representatives - International

Supplied and Supported by Fluke International Corporation, P.O. Box 43210, Mountlake Terrace, WA 98043, Tel: (206) 774-2398, TLX: 152662 JOHNFLUKE MTLT

ARGENTINA
Coasin S.A.
Virrey del Pino 4071
Buenos Aires, Argentina
Tel: 525130
TLX: 390122284 COASN AR

AUSTRALIA
Elmeasco Instruments Pty Ltd.
P.O. Box 30
Concord, N.S.W.
Australia 2137
Tel: (2) 736-2888
TLX: 79025887

Elmeasco Instruments Pty Ltd.
P.O. Box 107
Mt. Waverly, VIC. 3149
Australia
Tel: 233-4044
TLX: 26206 (ELMVIC)

Elmeasco Instruments Pty Ltd.
Professional Suite's Bldg.
B.P.O. Box 2360
Brisbane, 4001
Australia
Tel: (07) 229-3161

Elmeasco Instruments Pty Ltd.
P.O. Box 1240
G.P.O. Adelaide 5001
South Australia

BOLIVIA
Coasin Bolivia S.R.L.
Casilla 7295
La Paz, Bolivia
Tel: 40962
TLX: Public Booth # 5377, indicate "Para Coasin B.S.R.L., Av 6 de Agosto 2300 3er Piso, La Paz tl 40962"

BRAZIL
Arotec S.A.
Industria e Comercio
Av. Pacaembu 811
01234 Sao Paulo S.P., Brazil
Tel: (011) 67-2393
TLX: 1122207 AROT BR

Arotec S.A.
Rua Araguari, 1705 s 402
30.000 Belo Horizonte M.G., Brazil

Arotec S.A.
Av. Rio Branco 277
Grupo 1309
02000 Rio de Janeiro, R.J., Brazil
Tel: (021) 242-9776

BRUNEI
O'Connor's Limited
(Brunei Branch) Chin Kian Bldg.
P.O. Box 2126
Bandar Seri Begawan, Brunei
Tel: 26680

CHILE
Intronica Chile Ltda.
Manuel Montt 024 - Of. D
Casilla 16228
Santiago 9, Chile
Tel: 44940
TLX: 40301 Cab Publ.,
Attn: Intronica Chile

CHINA, PEOPLE'S REPUBLIC OF
China National Instrument Import & Export Corp.
P.O. Box 49, Erh-Li-Kou
Hsi Chi'ao
Beijing
People's Republic of China
TLX: CO 2242 CNIEC

COLOMBIA
Coasin Ltda.
Carrera 13, # 37-37, Of. 407
Ap. Aero 29583
Bogota DE, Colombia
Tel: 285-0230/0250
TLX: 45787 COASN CO

ECUADOR
Proteco Coasin Cia., Ltda.
Edificio "Jerico"
Ave. 12 de Octubre #2285 y
Ave. Oreliana (Planta Baja)
Quito, Ecuador
Tel: 529684
TLX: 2865 Protec Ed

Proteco Coasin Cia., Ltda
Casilla 9733
9 de Octubre 424
Edificio Gran Pasaje, Of. 1012
Guayaquil, Ecuador

HONG KONG
Gilman & Co., Ltd.
P.O. Box 56
Gilman Ind. Bldg. 9 F
107-109 Wai Yip Street
Kwun Tong, Kowloon
Hong Kong
Tel: 5-7909633
TLX: 73358 GILMN HX

ICELAND
Kristjan O. Skagfjord Ltd.
P.O. Box 906
Reykjavik, Iceland
Tel: 24120
TLX: 2133 KOS-1S

INDIA
Hinditron Services Pvt. Ltd.
69 A.L., Jagmohandas Marg
Bombay 400 006
India
Tel: 811316
TLX: 953-112326 Hspl In

Table A-4. Sales Representatives - International (cont)

Hinditron Services Pvt. Ltd.
"Hinditron House"
412 Raj Mahl Vilas Extension
Bangalore 560 006
India
Tel: 33139
TLX: 043741

INDONESIA
P.T. Dwi Tunggal Jaya Sakti
Sangga Buana Bldg., 1st Floor
Jl. Senen Raya 44, P.O. Box 4435
Jakarta, Indonesia
Tel: 367390-9
TLX: 46624 SABUANA 1A

P.T. Dwi Tunggal Jaya Sakti
Jalan Sasakgantung 45
Bandung, Indonesia
Tel: 367390-9
TLX: 46624 SABUANA 1A

JAPAN
John Fluke Mfg. Co., Inc.
Japan Branch
(PC Board Testers only)
1 Higashikata-machi
Midori-ku
Yokohama 226, Japan
Tel: (045) 473-5425
TLX: 3823-666 FLUKJPJ

Tokyo Electron Ltd.
38 Fl. Shinjuko Nomura Bldg.
1-26-2, Nishi-Shinjuku
Shinjuku-ku
Tokoyo 160, Japan
Tel: 03-343-4411
TLX: 2322220 LABTEL J

KENYA
Advanced Communications Ltd.
P.O. Box 30070
Nairobi, Kenya
East Africa
Tel: 331955
TLX: 22639 ADCOM

KOREA
Electro-Science Korea Co.
C.P.O. Box 8446
Room. 1201 Bowon Bldg.
490 Chongro - 5 Ka
Chongro-ku
Seoul, Korea
Tel: 261-7702
TLX: 78723270+

MALAYSIA
O'Connor's (PTE) Limited
P.O. Box 91
Petaling Jaya, Selangor
West Malaysia
Tel: 51563
TLX: OCONOR MA37649

O'Connor's (PTE) Limited
Lot # 5 Taman Mesra
Mile 3, Jalan Penampang
Kota Kinabulu
East Malaysia
Tel: 55322
TLX: MA80286FL

MEXICO
C.J. Christensen S.A. De C.V.
Instrumentos Electronicos
de Medicion
Melchor Ocampo 150-8
Mexico 4 D.F., Mexico
Tel: (905) 535-2258

NEW ZEALAND
W & K McLean Ltd.
P.O. Box 18065
Glen Innes
Auckland, New Zealand
Tel: 587-037
TLX: N.Z. 7912763

W & K McLean Ltd.
P.O. Box 2421
Christchurch, New Zealand

W & K McLean Ltd.
P.O. Box 496
Wellington, New Zealand
Tel: 851-450

NIGERIA
Mofat Engineering Co., Ltd.
P.O. Box 6369
Lagos, Nigeria
TLX: 21353, Attn: MOFAT

PAKISTAN
Pak International Operations
505 Muhammadi House
- McLeod Road
P.O. Box 5323
Karachi, Pakistan
Tel: 221127
TLX: 24494 PIO PK

PERU
Importaciones Y Representaciones
Electronicas S.A.
Avda. Franklin D. Roosevelt 105
Lima 1, Peru
Tel: 288650
TLX: 37425663

SINGAPORE
Rank O'Connor's (PTE) Limited
98 Pasir Panjang Road
Singapore 0511
Republic of Singapore
Tel: 637944
TLX: OCONSIN RS21023

SOUTH AFRICA
Fluke S.A. (Pty) Ltd.
P.O. Box 39797
Bramley 2018
Republic of South Africa
Tel: (011) 786-3170
TLX: 82899

TAIWAN
CCT Associates, Inc.
P.O. Box 24209
Taipei, Taiwan
Republic of China
Tel: (02) 391-6894
TLX: 24263 Longgulf

THAILAND
Dynamic Supply Engineering R.O.P.
56 Ekamai, Sukhumvit 63
Bangkok-11, Thailand
Tel: 914434
TLX: TH 82938 MONTIEN TH

URUGUAY
Coasin Uruguaya S.R.L.
Edif. Ciudadela
Sarandi 690 D. Esc. 109
Casilla de Correos 1400
Correo Central
Montevideo, Uruguay
Tel: 917978
TLX: Public Booth UY901 Coasin

VENEZUELA
Coasin C.A.
Apdo. Postal 50939
Sabana Grande # 1
Caracas 105, Venezuela
Tel: 782-9109-8741
TLX: 39531228

Latin America also Supported by -

Sr. Leonardo Cusnir, c/o COASIN A.A., Virrey del Pino 4071, Buenos Aires, Argentina, Tel: 523185, TLX: 390122284 COASN AR

Sr. Benewaldo Padovani, c/o AROTEC S.A., Industria e Comericio, Av. Pacaembu 811, 01234 Sao Paulo S.P., Brazil, Tel: (011) 67-2393, TLX: 1122207 AROT BR

Table A-4. Sales Representatives - International (cont)

Supplied and Supported by Fluke (Holland) B.V., P.O. Box 5053, Zevenheuvelenweg 53, 5004 EB Tilburg, Netherlands, Tel: (013) 673973, TLX: 522337

AUSTRIA
Walter Rekirsch
Electronische Gerate GmbH & Co.
Vertriebs-KG
Liechtensteinstrasse 97/6
A-1090 Vienna, Austria
Tel: (222) 347646
TLX: 134759

BELGIUM
Fluke (Belguim) S.A./N.V.
6 Rue de Geneve
1140 Brussels, Belgium
Tel: (2) 2164090
TLX: 26312

BULGARIA
Amtest Associates Ltd.
P.O. Box 55
Addlestone, Surrey KT15 1DU
United Kingdom
Tel: Weybridge (923) 52121
TLX: 928855

CHAD
Fluke (Holland) B.V.
P.O. Box 5053,
Zevenheuvelenweg 53
5004 EB Tilburg, Netherlands
Tel: (013) 673973
TLX: 52237

CYPRUS
Chris Radiovision Ltd.
P.O. Box 1989
Nicosia, Cyprus
Tel: 66121
TLX: 2395

CZECHOSLOVAKIA
Amtest Associates Ltd.
P.O. Box 55
Addlestone, Surrey KT15 1DU
United Kingdom
Tel: Weybridge (932) 52121
TLX: 928855

DENMARK
Tage Olsen A/S
Ballerup Byvej 222
DK - 2750 Ballerup, Denmark
Tel: (2) 658111
TLX: 35293

EGYPT AND SUDAN
Lotus Engineering Organisation
P.O. Box 1252
22, Kasi El Nil
Cairo, Egypt
Tel: 971617
TLX: 92504

EIRE (REPUBLIC OF IRELAND)
Euro Electronics
32 Brews Hill
Naven, County Meath
Tel: 46-23577
TLX: 31821

ETHIOPIA
Fluke (Holland) B.V.
P.O. Box 5053,
Zevenheuvelenweg 53
5004 EB Tilburg, Netherlands
Tel: (013) 673973
TLX: 52237

FINLAND
Oy Findip AB
Teollisuustie 7
02700 Kauniainen, Finland
Tel: (0) 502255
TLX: 123129

FRANCE
M.B. Elctronique S.A.
Rue Fourny
ZAC de BUC
B.P. # 31
78530 BUC, France
Tel: (1) 9568131
TLX: 695414

GERMAN DEMOCRATIC REPUBLIC
Amtest Associates Ltd.
P.O. Box 55
Addlestone, Surrey KT15 1DU
United Kingdom
Tel: Weybridge (932) 52121
TLX: 928855

GERMAN FEDERAL REPUBLIC
Fluke (Deutschland) GmbH
Krausstrasse 55
8045 Ismaning
West Germany
Tel: (089) 96251
TLX: 0522472
Rapitax: (089) 966718

Fluke (Deutschland) GmbH
Meineckestrasse 53
4000 Dusseldorf 30
West Germany
Tel: (0211)450831
TLX: 8585576

Fluke (Deutschland) GmbH
Oberer Kirchhaldenweg 135
7000 Stuttgart 1
West Germany
Tel: (0711) 694091
TLX: 722518

PK Electronik
Lietzenburger Strasse 91
1000 Berlin 15
West Germany
Tel: (030) 8831058

GREECE
Hellenic Scientific
Representations Ltd.
11, Vrasside Street
Athens 615, Greece
Tel: (1) 711140
TLX: 219330

HUNGARY
Amtest Associates Ltd.
P.O. Box 55
Addlestone, Surrey KT15 1DU
United Kingdom
Tel: Weybridge (932) 52121
TLX: 928855

IRAN
Irantronics Company Ltd.
20. Salm Road
Roosevelt Avenue
Tehran, Iran
Tel: 828294/831564
TLX: 212956/212876

IRAQ
Fluke (Holland) B.V.
P.O. Box 5053,
Zevenheuvelenweg 53
5004 EB Tilburg, Netherlands
Tel: (013) 673973
TLX: 52237

IRELAND
Euro Electronics
32 Brews Hill
Naven County Meath
Ireland
Tel: (46) 23577
TLX: 3182

ISRAEL
R.D.T. Electronics Engineering Ltd.
P.O. Box 75
46, Sokolov Street
Ramat Hasharon 47235
Israel
Tel: (3) 483211
TLX: 32143

ITALY
Sistrel S.p.A.
Via Giuseppe Armellini # 37
00143 Rome, Italy
Tel: (6) 5915551
TLX: 680356

Sistrel S.p.A.
Via Timavo 66
20099 Sesto S. Giovanni (Milan)
Italy
Tel: (2) 2476693
TLX: 320346

Sistrel S.p.A
Via Cintia
Parco S. Paolo 35
80126 Naples, Italy
Tel: (81) 7679700

KUWAIT
Tareq Company
P.O. Box Safat 20506
Kuwait, Arabian Gulf
Tel: 436100/436045
TLX: 2315

Table A-4. Sales Representatives - International (cont)

LEBANON AND JORDAN
Mabek (Electronics Division)
P.O. Box 11-3823
Beirut, Lebanon
Tel: 252631/348728
TLX: 22889

LIBYA
Fluke (Holland) B.V.
P.O. Box 5053,
Zevenheuvelenweg 53
5004 EB Tilburg, Netherlands
Tel: (013) 673973
TLX: 52237

MOROCCO
Mainvest
Residence Moulay Ismail
Bat. C.
Boulevard Moulay Slimane
Rabat, Morocco
Tel: (7) 27664
TLX: 31036

NETHERLANDS
Fluke (Nederland) B.V.
P.O. Box 5053,
Zevenheuvelenweg 53
5004 EB Tilburg, Netherlands
Tel: (013) 673973
TLX: 52237

NORWAY
Morgenstierne & Co. A/A
Konghellegate 3
P.O. Box 6688, Rodelokka
Oslo 5, Norway
Tel: (2) 356110
TLX: 11719

PDR YEMEN
Fluke (Holland) B.V.
P.O. Box 5053,
Zevenheuvelenweg 53
5004 EB Tilburg, Netherlands
Tel: (013) 673973
TLX: 52237

POLAND
Amtest Associates Ltd.
P.O. Box 55
Addlestone, Surrey KT15 1DU
United Kingdom
Tel: Weybridge (932) 52121
TLX: 928855

PORTUGAL
Equipamentos de Laboratorio, Ltda.
P.O. Box 1100
1002 Lisbon, Portugal
Tel: (1) 578936/547512
TLX: 18469

QATER, OMAN &
UNITED ARAB EMIRATES
Technology Organisation
P.O. Box 5549
Doha, Qatar
Tel: 321431
TLX: 4581

ROMANIA
Amtest Associates Ltd.
P.O. Box 55
Addlestone, Surrey KT15 1DU
United Kingdom
Tel: Weybridge (932) 52121
TLX: 928855

SAUDI ARABIA
Electronic Equipment
Marketing Co. Ltd.
P.O. Box 3750
Riyadh, Saudi Arabia
Tel: 32761/32700/37023
TLX: 201120

SOMALIA
Fluke (Holland) B.V.
P.O. Box 5053,
Zevenheuvelenweg 53
5004 EB Tilburg, Netherlands
Tel: (013) 673973
TLX: 52237

SPAIN
Hispano Electronica S.A.
Piligono Industrial Urtinsa
Apartado de Correos 48
Alcorcon (Madrid)
Spain
Tel: (1) 6194108
TLX: 22404/42634

SWEDEN
Teleinstrument AB
P.O. Box 490
S-162 04 Vallingby 4
Sweden
Tel: (8) 380370
TLX: 11347

SWITZERLAND
Traco Electronic Company Ltd.
I. Jenatschstrasse
Postfach, 8027 Zurich
Switzerland
Tel: (1) 2010711
TXL: 54318

SYRIA
Mabek (Electronics Division)
P.O. Box 4238
Damascus, Syria

TURKEY
Erkman Electronik Aletler
Ticaret Anonim Sirketi
Necatiby Cad 92/3
Karakoy, Istanbul, Turkey
Tel: (1) 5461
TLX: 23353

UNITED KINGDOM
Fluke International Corp.-UK
Colonial Way
Watford, Herts, WD 24 TT
United Kingdom
Tel: (923) 40511

U.S.S.R.
Amtest Associates Ltd.
P.O. Box 55
Addlestone, Surrey KT15 1DU
United Kingdom
Tel: Weybridge (932) 52121
TLX: 928855

YEMEN
Fluke (Holland) B.V.
P.O. Box 5053,
Zevenheuvelenweg 53
5004 EB Tilburg, Netherlands
Tel: (013) 673973
TLX: 52237

YUGOSLAVIA
Amtest Associates Ltd.
P.O. Box 55
Addlestone, Surrey KT15 1DU
United Kingdom
Tel: Weybridge (932) 52121
TLX: 928855

Customers in the following countries: Bulgaria, Czechoslovakia, Hungary, Poland, Romania, U.S.S.R., and Yugoslavia, contact: Amtest Associates Ltd., P.O. Box 55, Addlestone, Surrey, KT 15 1DU, England, Tel. (0932) 52121

John Fluke Mfg. Co., Inc.

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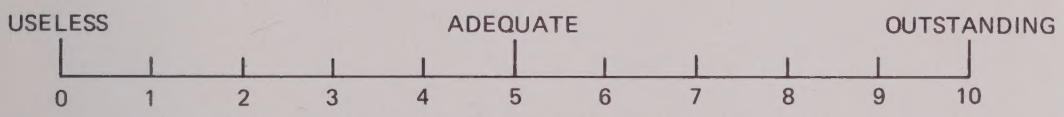

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